# Model of OFF-ON transition and SET process in phase-change memory

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Resistivity variation between amorphous and (poly)crystalline states of chalcogenide film (ChF) can be utilized in non-volatile memories [1,2] based on Ovshinsky effect [3] which is already used for discrete devices [4]. Regardless initial state of sputtered film the first RESET step leads to the vitrification of a ChF in active area of a memory cell. We analyze the following scenario: *a) Auger recombination of electrons at -U centers and free holes → b) change of atoms positions due to shake-up effect → c) release of polaron energy during -U centers destruction and Fermi level de-pinning → d) generation of localized high frequency vibrations in clusters at former -U centers → e) local over-heating and expansion of these medium range clusters → f) delayed heat transfer to compressed intercluster regions → g) decrease of the activation energy for conductivity → h) increase of carriers concentrations (and probably mobility) due to steps e, f, and g → i) the OFF-ON transition* as the major stages of the electron induced thermal transformation in atom subsystem between the vitreous and crystalline states of ChF [5]. Distinctiveness of –U centers in $Ge_2Sb_2Te_5$ film is discussed. This scenario allows to explain various features observed during the OFF-ON transition in first and second generations of ChF [1-3]. It is shown for instance that instability of dynamic negative resistance observed often during the first firing of ChF [2] can be described in the terms of Auger recombination processes. The pressure and light influences on the OFF-ON transition in ChF are discussed, the importance of low-temperature data is emphasized.
The collective re-arrangement of atoms and vacancies (probably Te and Sb/Ge in $Ge_2Sb_2Te_5$ film) explains abnormally high activation energies (~ 2 eV to compare with optical gap ~ 0.8eV) and frequency factors (~ $10^{25}$ to compare with typical phonons values ~$10^{13}$ Hz) often observed in experiments modeling SET process. We find relations between ChF parameters and the vitrification temperature, melting point and maximum crystallization temperature that allow better select ChF for phase-change memories.

<u>References:</u>

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